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PATENT

CLIMATIC DEVICE, AND PROCESS FOR DEFROSTING A HEAT EXCHANGER IN A CLIMATIC DEVICE

The invention pertains to a climatic device comprising a working space and an equipment space, which is connected thereto via at least one connection opening, whereby a heat exchanger is arranged in the aforementioned equipment space. In addition, the invention pertains to a process for operating the climatic device.

In the present context, the term climatic device is to be understood to mean a device that permits the creation of a defined climate in a working space. The climate is defined, in particular, by the temperature, humidity, and composition of the gas that is present therein. In the area of biological sciences and medicine, in particular, objects frequently must be stored for a defined period of time under specific climatic conditions. Open dishes, closed containers, so-called microtiter plates, and similar containers for accommodating samples are also to be understood as constituting said objects.

Climatic device are known from the prior art. Thus, DD-PS 141706 discloses a test chamber for simulating climatic parameters. The test chamber has a working space and an outer space in which a heat exchanger is arranged. The gas in the working space is led into the outer space via a suction opening and is then circulated around the heat exchanger and re-supplied to the working space via an inlet opening.

Icing up of the heat exchanger, which has gas flowing around it, occurs as an unavoidable problem during the operation of a climatic device when, in particular, the working space is to be thermostatically regulated to temperatures below the freezing point. The heat exchanger must therefore be defrosted regularly.

Various processes are known for defrosting heat exchangers, such as defrosting by means of a hot gas, and defrosting by use of electrical heat. The transformation of ice into liquid and, finally, the formation of water vapor via the vapor pressure of the liquid arise independently of the procedure as a result of the defrosting process. The phase transition from liquid to gaseous water is associated with a relatively large increase in volume. During defrosting, there results a significant increase in the humidity of the gas that surrounds the defrosting heat exchanger.

The gas, which has been made very damp as a result of the defrosting process, is transported into the working space as a result of the exchange of gas between the space, in which the heat exchanger is arranged and the working space. At a working space temperature that is below the freezing point, the moisture that derives from the defrosting process condenses in the form of a layer of frost or ice on the objects that are located in the working space, and on the storage devices that hold the objects, and on any transport system that is possibly present.

In an extreme case, this undesired formation of frost and ice can lead to the situation in which the objects freeze tight to the storage device. As a result, the removal of the objects from the storage device or the working space is no longer directly possible either manually or via an automated transport system.

The problem that therefore forms the basis of the present invention is to indicate a climatic device and a process of the initially mentioned type that prevent the formation of frost and ice in the working space as a result of the defrosting process.

This problem is successfully solved by the climatic device in accordance with Claim 1, as well as with the process in accordance with Claim 20. Preferred embodiments of the device and preferred process variants can be seen in the dependent claims in question.

In accordance with the device, the problem is solved for a climatic device as described initially by means of the feature that, at the connection opening between the working space and the equipment space, there being at least one such opening, a blocking device is arranged with which the exchange of gas between the working space and the equipment space can be selectively suppressed.

As a result of the blocking device in accordance with the invention, the situation is prevented in which wet gas from the equipment space can get into the working space when defrosting the heat exchanger. Consequently, the formation of frost and ice, especially on stored objects, is prevented at temperatures of the working space that are below the freezing point. In addition, the objects cannot freeze tight to the storage device that is holding them, as a result of which problem-free removal of the objects from the storage device is possible even after defrosting the heat exchanger several times. Moreover, the formation of a layer of

frost or ice on any transport system, which is possibly present in the working space, is also effectively prevented.

As an additional advantage, the device in accordance with the invention prevents any undesired increase in relative humidity, so-called re-humidification, in the working space in the case of a working space temperature that is above the freezing point. As a result, it is not possible for objects that are stored in the working space to become damaged or even destroyed by means of the increase in humidity.

In a first preferred embodiment, the blocking device is a device for forming a curtain of gas transversely to the connection opening. As a result of the fact that the connection opening(s) is/are covered with a curtain of gas over its/their total cross section, one therefore prevents the situation in which gas from the equipment space can cross over into the working space. This blocking device does not have any movable mechanical parts, but nevertheless reliably prevents the exchange of gas between the equipment space and the working space.

The curtain of gas is expediently produced by at least one gas blower opening, and preferably several gas blower openings. The gas blower opening, there being at least one such opening, can basically be arranged anywhere in the region of the connection opening as long as the site of application and the size of the opening ensure that the opening cross section of the connection opening is covered completely by the flow of gas. A slot-type nozzle, for example, can serve as the gas blower opening. Alternatively, several small nozzles can be used for covering the opening cross section.

The gas blower openings can be arranged both inside and outside the connection opening.

It is conceivable, for example, for the gas blower openings to be arranged outside the connection opening in the working space, namely in the region that is adjacent to the working space end of the connection opening, in such a way that the outflow openings of the gas blower openings point in the direction of the equipment space. The gas flow then streams through the connection opening from the inside and in the direction of the outer end.

However, it is preferred that the gas blower openings be arranged in the connection opening in order not to reduce the size of the working space that is available. It is possible,

for example, to arrange the gas blower openings in the region of the connection opening walls that define the connection opening. The length of the connection opening is hereby determined in the usual way by the thickness of the wall that separates the working space from the equipment space. However, it is also possible to extend the connection opening beyond the thickness of the lateral walls, and to allow the connection opening walls to project into the interior of the working space or, preferably, into the equipment space.

A gas curtain, that covers the cross section of the connection opening can be achieved realized reliably if several gas blower openings are used for forming the gas curtain. For example, gas blower openings can be located on opposing sides or all sides of the connection opening.

The number of gas blower openings is a function of the size of the connection opening and should in any case be adequate to ensure a flow of gas that prevents the penetration of air from the equipment space into the connection opening. In this regard, it can be expedient to arrange several rows of gas blower openings in the connection opening. A large number of gas blower openings per unit area, for example, can be realized via a staggered arrangement of gas blower openings.

Instead of gas blower openings in the lateral walls of the connection opening, one or more gas supply lines with gas blower openings in the walls of the supply lines can also be installed in the connection opening. For example, one or more gas supply lines with openings that have been introduced into the wall of the supply line can be installed in the connection opening in a linear manner, a meandering manner, or a spiral manner.

It can also be expedient to set up the flow direction of the gas blower openings in a specific fashion. For example, it is possible to align at least some of the gas blower openings obliquely in the direction of the equipment space. As a result, a flow of gas arises in the direction of the outer entrance of the connection opening and away from it, and the penetration of ambient air is made additionally difficult. It is not basically necessary for this purpose that all the gas blower openings be aligned in the direction of the outside of the connection opening, but it is currently preferred.

In the case of applying a large number of gas blower openings in the walls of the connection opening, one can surround -- at least in those areas in which the gas blower openings are present -- the connection opening with a chamber, which is filled with the gas and from where the gas then gets into the gas blower openings that are connected to the gas collection chamber, where this is done for the purpose of achieving a uniform and simple gas supply. Thus, only a single gas supply line is necessary, which opens out into the gas collection chamber.

In addition to or instead of the application of gas blower openings in the connection opening, at least one gas blower opening can also be provided outside the connection opening adjacent to an entrance of the connection opening. The possibility has already been mentioned of application on the side where the working space is located. However, application is preferred on the side where the equipment space is located. As in the case of gas blower openings in the walls of the connection opening, the gas blower openings can in this case also be present on both sides either entirely or partially around the connection opening. Here also an arrangement of several rows of gas blower openings one above another can be useful at the side of the opening in order to form an adequately thick gas curtain. In order to do this, a gas supply line with openings introduced in the wall of the supply line can be wrapped around the connection opening, e.g., in a spiral manner.

As in the case of the gas blower openings that are arranged in the connection opening, the gas blower openings, which are present on the outside in front of the connection opening, can be oriented in such a way that gas does not flow out exactly parallel to the opening cross section, but rather is directed somewhat away from the connection opening.

Any suitable gas can basically be used as the gas in regard to the atmosphere that is present in the working space of the climatically controlled cabinet. Essentially anhydrous gases and/or inert gases (buffer gases) are preferably used, e.g., dried air, nitrogen, or carbon dioxide. Nitrogen is currently preferred. This has the advantage that nitrogen supply lines that are usually present in laboratories can be used; optionally a reducing valve to reduce the pressure to a suitable preliminary pressure of e.g., 1 bar can be used.

In another preferred embodiment, which can optionally be used as a blocking device in combination with the curtain of gas, the feature is provided that the blocking device is a

mechanical seal. This can be a flap for example, and, in particular, an automatically closing flap, which is, e.g., pre-tensioned in elastic fashion, in order to block the connection opening until a predetermined pressure difference is reached between the working space and the equipment space. Alternatively, a sliding valve is also possible as a mechanical seal. In this case, the term sliding valve should be understood to mean not only a linearly displaceable seal, but also a sliding valve that is rotatable about a pivot axis.

It is especially advantageous if the sliding valve is applied to the side of the connection opening where the working space is located, and if it can be actuated by means of a transport system arranged in the working space. If a transport system, which is in any case present in the working space for transporting objects, is also used for actuating the seal, then no additional actuation system is required for the seal, and external interventions by operating personnel are superfluous. Alternatively, however, the mechanical seal can also be actuated manually, by a motor-driven system, or electromagnetically.

In order to prevent the situation in which the mechanical seal acts as a cold bridge between the equipment space and the working space, thereby leading to negative effects on the temperature of the working space, the heat transfer properties of the seal should be reduced as much as possible. In order to effect this, the seal can be thermally insulated or heated or can be made from a material of low thermal conductivity.

The climatic device in accordance with the invention is preferably designed in such a way that it can be largely operated automatically as far as is possible. For this purpose, a control device is present that can be used, inter alia, to control the blocking device in such a way that its coming into operation is coupled to the operating state of the heat exchanger and/or the temperature in the equipment space. This permits the blocking device not only to be automatically activated in the case of an intentional start of a defrosting process, and optionally deactivated once again after finishing the defrosting process, but also to be set automatically in operation in the case of an inadvertent malfunction of the heat exchanger (as a result of a power outage or similar occurrence) and an associated increase in temperature in the equipment space.

In addition to placing the blocking device in operation, an aspirating extraction device, such as an extraction fan, can also be started up that conveys moist air from the

equipment space into the external surroundings of the climatic device, thereby contributing to dehumidification in the equipment space. The extraction fan can be arranged, for example, in the region of the pressure equalization opening of the climatic device.

In another regard, the invention pertains to a process for operating the climatic device that has been described above, such that the control device sets the blocking device into operation and interrupts the operation of the heat exchanger at the same time as the activation of the blocking device, or after the activation thereof. In a variant of the process, the blocking device is put out of operation once again when the heat exchanger is placed in operation again. In another variant, by contrast, which can be considered for a blocking device with the formation of a curtain of gas, the operation of the blocking device is not interrupted after the heat exchanger is placed in operation. In other words, the supply of gas continues even in the case where the heat exchanger is switched on, i.e., during the regular operation of the climatic device. As a result, the gas that is supplied also builds up in the working space. This may have the advantage of the gas contributing to a positive effect on the atmosphere in the working space. This is the case, for example, if the humidity in the working space is reduced by admitting dry gas, or if an inert gas, such as nitrogen, builds up in the working space and thus contributes to the protection of air-sensitive objects that are being stored in the working space. This can also be important for certain incubation applications if carbon dioxide is admitted as the gas for expulsion purposes.

The fan that is arranged in the equipment space can be switched on in order to assist the admission of gas into the working space. However, it is also possible to carry out the gas expulsion process during the defrosting of the heat exchanger, i.e., with the fan switched off. Upon deactivating the blocking device, the fan is advantageously switched on again in order to actuate climatic control.

The invention will be explained further in the following section by means of the drawings. The following features are shown schematically.

Figure 1 shows a sectional illustration of a first preferred embodiment example of a climatic device in accordance with the invention, namely during the defrosting process;

Figure 2(a) shows a partial plan view of a connection opening of another example of a climatic device in accordance with the invention;

Figure 2(b) shows a cross section along line A-A in Figure 2(a);

Figure 3 shows a plan view of a connection opening of a further example of another climatic device in accordance with the invention;

Figure 4 shows an additional example of a climatic device in accordance with the invention in the form of an illustration that corresponds to Figure 1;

Figure 5 shows another example of a climatic control apparatus in accordance with the invention in the form of an illustration that corresponds to Figure 1.

Figure 1 shows a climatic device 1 that essentially corresponds to the prior art except for the configuration in the region of the connection openings 5 in a wall 14 that separates a working space 2 from an equipment space 3. A heat exchanger 4 is arranged in the equipment space 3 in order to acclimatize the working space 2. The gas atmosphere, which is located in the interior of the climatic device 1, is circulated through the equipment space 3 via the connection openings 5 and the working space 2 by means of a fan 13 that is located in the equipment space 3. A heatable pressure equalization opening 12 serves for equalizing the positive or negative pressure in the device 1.

During normal climatic control operation, the circulated masses of air can flow unhindered through the connection openings 5 from the working space 2 and into the equipment space 3 and back again. The fan 13 is switched off and the blocking device 6 is activated when the heat exchanger 4 is also switched off for defrosting purposes.

The blocking device 6 is arranged in the region of the two connection openings 5. In each case, it comprises two gas supply lines 9, which run essentially over the entire breadth of the connection openings 5, whereby these gas supply lines are arranged along two opposite sides of the connection openings 5. If the blocking device 6 is activated, then a gas 7' flows out of the gas supply lines 9 at a defined gas pressure. In order to obtain a gas curtain 7, that covers the entire cross section of the connection opening 5 in question, several gas blower openings 8 are present over the entire length of each gas supply line 9 (i.e., vertically to the

plane of the drawing). There are two rows of gas blower openings 8, which point toward the equipment space 3, for each gas supply line 9, whereby gas 7' flows obliquely away to the outside from the gas supply lines. As a result, a gas curtain 7 transverse to the connection opening 5 is created, this gas curtain prevents the penetration of moist gas, which is located in the equipment space 3, into the connection openings 5.

A positive pressure, which builds up as a result of the permanent inward flow of gas 7' during the defrosting process, is equalized by the pressure equalization opening 12. The pressure equalization opening 12 is heatable in order to ensure that it does not freeze up by the cold and moist gas that flows through it.

The definition of the gas pressure of the outward flowing gas 7' and the number of gas blower openings 8 determines not only the thickness of the gas curtain 7 but also the volume of the flow of gas 7' that is led off to the outside from the equipment space 3 via the pressure equalization opening 12. The gas 7' entrains moisture and coldness in the equipment space 3 to the outside via the gas equalization opening 12. Thus, the defrosting process for the heat exchanger 4 is actively assisted by the admitted gas 7'.

The blocking device 6 can also be used for modifying the atmosphere in the working space 2. Gas 7' also penetrates into the working space 2 and expels the gas that is present there even during the defrosting of the heat exchanger 4. In order to increase the gas volume that is exchanged, the supply of gas 7' can be extended beyond the time of defrosting and can take place uninterruptedly, for example. The complete exchange of the atmosphere in the working space by gas 7' can thus be achieved with a supply of gas adequate in strength for a sufficient period of time.

Figure 2(a) is a plan view of a connection opening 5 from the side of the equipment space 3. Apart from the configuration in the region of this connection opening 5, the remaining climatic device, which is not illustrated in the diagram, corresponds to that of Figure 1. Instead of the gas supply lines 9 that are arranged in the connection openings in Figure 1, the gas supply lines in the device in accordance with Figure 2 are applied outside the connection openings 5. Two gas supply lines 9 run along opposite sides of each of the connection openings 5 on the side of the wall 14 that points toward the equipment space 3.

Gas blower openings 8 are present in the gas supply lines 9, covering the cross section with a curtain of gas and allowing gas 7' to flow away via the connection opening 5.

As can be seen from Figure 2(b), the flow of gas out of the gas blower openings 8 is directed somewhat away from the entrance of the connection opening 5 and runs obliquely into the equipment space 3. Penetration of moist air from the equipment space 3 can be prevented even more certainly as a result of the flow of gas 7' away from the connection opening 5.

Figure 3 is a plan view of a connection opening 5 of a further example of an embodiment of a climatic device in accordance with the invention which, except for the differences that have been indicated, again corresponds basically to the climatic device described in the figures above. The view shows the end of the connection opening 5 at the side where the equipment space is located. Here, the gas curtain that covers the cross section of the connection opening 5 is produced by gas blower openings 8 that are arranged in the interior of the connection opening 5. 5 rows of 5 gas blower openings in each case are present in the region of the left lateral wall 5a, and are uniformly distributed over its surface. These gas blower openings 8 pass through the lateral wall 5a and open out into a gas collection chamber 17 that surrounds the connection opening 5; it is illustrated more clearly by the dotted line and is supplied with gas via a gas connection. This gas collection chamber 17 serves for building up a preliminary gas pressure and for distributing the gas uniformly.

As in the case of the wall 5a, gas blower openings are also present in the wall 5b on the side opposite the wall 5a. As a result of the uniform distribution of gas blower openings 8 in the region of the lateral connection opening walls 5a and 5b, which surround the connection opening 5, a wider gas curtain can be produced over the entire length of the connection opening 5, namely from the inner entrance on the side of the working space 2 to the outer entrance on the side of the equipment space 3, whereby this wider gas curtain covers the entire opening cross section of the connection opening 5. As a result, the penetration of moist air into the working space 2 can be reliably prevented. The penetration of air can be suppressed still better if the gas blower openings 8 run in an oblique manner in the direction of the equipment space 3 with their openings pointing into the connection opening 5. As a result, a flow of gas arises that is directed out of the connection opening 5 and into the direction of the equipment space 3.

Figure 4 illustrates another preferred embodiment of the invention. In order to prevent an exchange of gas between the working space 2 and the equipment space 3, the connection openings 5 are in each case sealed off by a blocking device 6' in the form of a mechanical seal. The mechanical seal is a sliding valve 10 that has a grasping element 11. The sliding valve 10 can be displaced by a sliding force that acts upon the grasping element 11, as a result of which the connection opening 5 closes or opens. In the case shown, displacement takes place in the right-left direction in the plane of the paper. Alternatively, rotation of the given sliding valve is also conceivable about an axis of rotation opposite the grasping element.

Here, the displacement of the sliding valve 10 takes place via a transport system 15 arranged in the working space 2 for objects that are stored in the working space, namely in the form known from, e.g., DE 10024581. The transport system 15 that is arranged in the working space thus serves both for actuating the mechanical seal and also for transporting the objects within the working space 2. In order to actuate the sliding valve 10, the blade 16 of the transport system 15 pushes the sliding valve 10 in the direction of the middle of the working space by applying a sliding force to the grasping element 11. The connection opening 5 opens as a result.

The sliding valve 10 can be thermally insulating, or it can be heatable in order that coldness not be transferred from the equipment space 3 into the working space 2.

Figure 5 shows a variant that corresponds to Figure 4, wherein flaps 18 and 19 are present as seals for the connection openings 5 instead of the sliding valve. These flaps can also be thermally insulating or heatable. The flaps are shown in the closed state, i.e., in the state adopted during a defrosting process. During regular operation of the climatic device 1, the flaps 18, 19 are opened by pivoting about a holding device installed in the region of the edges 20. The opening of the flaps 18, 19 is brought about by the stream of air that is produced by the fan 13. Accordingly, the flap 18 for the air that is flowing out of the working space 2 and toward the equipment space 3 (made clear by the arrows) is located on the side where the equipment space is located, whereas the flap 19 for air that flows from the equipment space 3 and into the working space 2 is located on the side where the working space is located. The flaps 18, 19 close by themselves when the fan 13 is switched off. This can be achieved, for example, by means of spring elements (not shown in the drawing).

If the heat exchanger 4 and the fan 13 are switched off for defrosting purposes, then no additional steps are necessary in order to close the flaps 18 and 19, and thus to suppress the penetration of moist and cold air into the working space.